MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2018 / 2019

PPH0135 - ELECTRICITY AND MAGNETISM

(Foundation in Engineering)

16 OCTOBER 2018
9.00 a.m. – 11.00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of **FIVE** printed pages, excluding the cover page and appendices, with **FIVE** questions.

2. Answer all questions. The distribution of the marks for each question is given.

3. Write all your answers in the answer booklet provided.

4. All necessary workings must be shown.

QUESTION 1 (10 marks)

a) Two point charges, $q_1 = +3.0\ \mu C$ and $q_2 = +5.0\ \mu C$ are 12.0 cm apart on an x- axis as shown in **Figure Q1.1**. Point P is located on the x-axis between the charges.

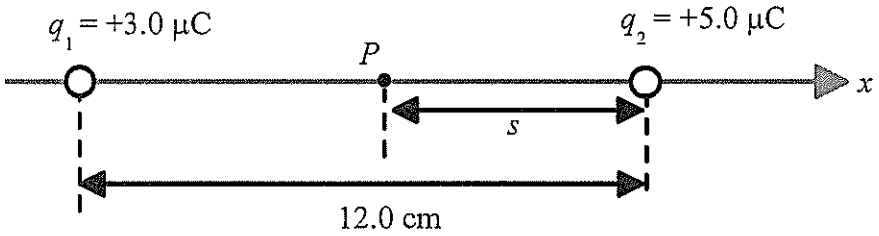

Figure Q1.1

i. Draw the direction of electric fields at point P due to each of the charges. Label them as E_1(electric field due to q_1) and E_2 (electric field due to q_2).

(2 marks)

ii. If the resultant electric field at point P is zero due to the two charges, determine the value of s.

(3 marks)

b) A parallel plate capacitor $C_1 = 10.0\ \mu F$, is charged by connecting it to a 6-V battery ,as shown in **Figure Q1.2a**. After capacitor C_1 is fully charged, it is disconnected from the battery and is then connected across an uncharged parallel plate capacitor $C_2 = 8.0\ \mu F$, as shown in **Figure Q1.2b**.

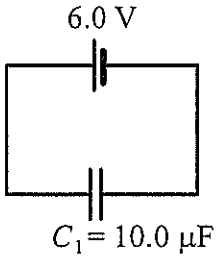

Figure Q1.2a

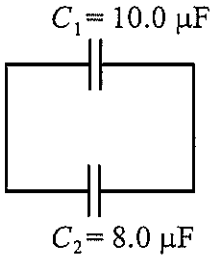

Figure Q1.2b

i. What is the charge stored in C_1 in **Figure Q1.2a**?

(1 mark)

ii. What is the equivalent capacitance in **Figure Q1.2b**?

(1 mark)

iii. Calculate the final charge on each of the capacitors in **Figure Q1.2b**.

(3 marks)

Continued...

QUESTION 2 (10 marks)

a) An electrical heater connected to a *DC* voltage of 120.0 V consumes 80.0 W of power.

i. How much current flows through the heater?

(1 mark)

ii. How long does it take for 15 million electrons to pass the heater?

(2 marks)

b) Four resistors are connected in a circuit shown in **Figure Q2**.

i. Write the equation of Kirchhoff's current law applied at point *F*.

(0.5 marks)

ii. Write the equation of Kirchhoff's voltage law to loop *BAFCB* and loop *CFEDC*.

(2 marks)

iii. Based on parts (i) and (ii), determine I_1.

(1.5 marks)

iv. If load resistor $R_L = R_3$, determine the Thevenin resistance and Thevenin voltage of the circuit.

(2 marks)

v. Based on part (iv) find the value of current flowing through $R_L = R_3$.

(1 mark)

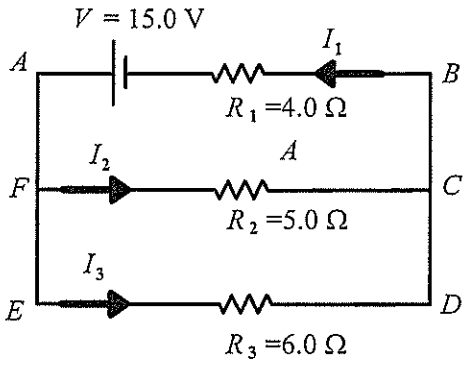

Figure Q2

QUESTION 3 (10 marks)

a) A proton moving in a circular path perpendicular to a constant magnetic field takes 1.2 μs to complete one revolution. Determine the magnitude of the magnetic field.

(2 marks)

Continued...

b) A single-turn circular loop of radius 0.10 m and resistance 5.00 Ω is coaxial with a solenoid of length 0.80 m and a radius of 0.04 m with 1500 turns. A variable resistor, as indicated in **Figure Q3.1** is varied in such a way that the solenoid current decreases linearly from 3.00 A to 0.500 A in 0.20 s. What is the magnitude of the induced current in the loop?

(4 marks)

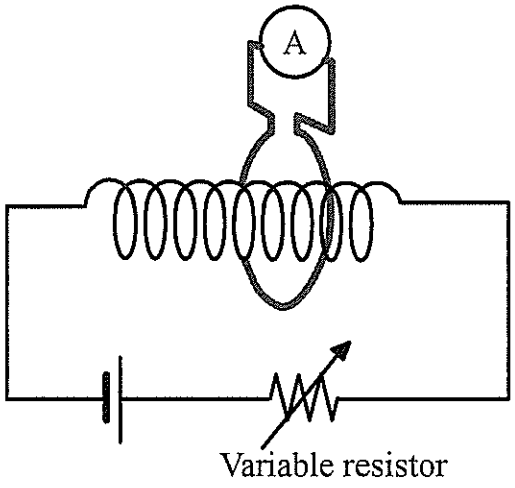

Figure Q3.1

c) A metal rod with a length of 30.0 cm and mass of 12.0 g carries a current of $I = 12.0$ A. The rod hangs from two wires in a uniform vertical magnetic field as shown in **Figure Q3.2**. The wires make an angle $\theta = 30°$ with the vertical when in equilibrium.

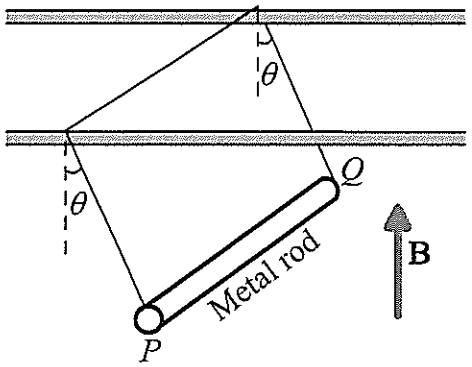

Figure Q3.2

i. What is the direction of current flowing through the rod (P to Q or Q to P)?

(1 mark)

ii. Determine the magnitude of the vertical magnetic field.

(3 marks)

Continued...

QUESTION 4 (10 marks)

a) A 25-Ω resistor is connected across a power supply that produces an instantaneous voltage given by equation $v = (140.0\ \text{V}) \sin (120\pi\ \text{t})$

i. Calculate the frequency of the voltage source.

(1 mark)

ii. What is the *rms* current passing through the resistor?

(2 marks)

iii. What is the power dissipated on the resistor?

(1 mark)

b) An inductor is connected in series with a resistor with a resistance of 150.0 Ω. When these are placed in series across an *rms* 110.0 V *AC* source with frequency of 120.0 Hz, the *rms* voltage across the resistor is 40 V.

i. What is the *rms* current flowing in the circuit?

(1 mark)

ii. Determine the impedance of the circuit.

(1 mark)

iii. Calculate the inductance of the inductor.

(2 marks)

iv. What is the value of a capacitance to be added in series to the inductor and resistor so that the circuit will be in resonance?

(2 marks)

Continued...

QUESTION 5 (10 marks)

a) **Figure Q5.1** shows a block diagram of a *pn* junction. Depletion region is formed in the region near the junction.

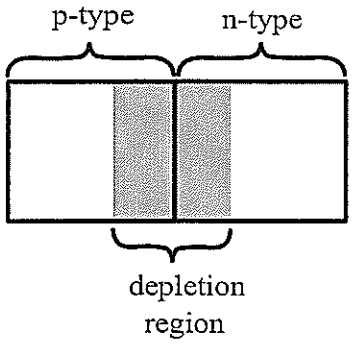

Figure Q5.1

i. Describe the formation of depletion region in *pn* junction.

(2 marks]

ii. Explain what will happen to the depletion region of a *pn* junction in forward bias condition.

(2 marks)

b) **Figure Q5.2** shows a circuit of germanium bipolar junction transistor. If α_{dc} is 0.98, determine I_B, I_C and I_E in the circuit.

(6 marks)

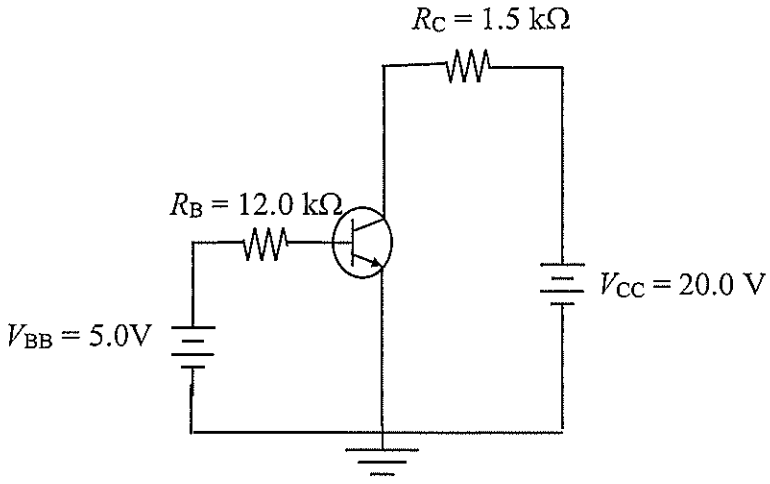

Figure Q5.2

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APPENDIX I

Physical Constants

Quantity	Symbol	Value
Electron mass	m_e	9.11×10^{-31} kg
Proton mass,	m_p	1.67×10^{-27} kg
Elementary charge	e	1.602×10^{-19} C
Gravitational constant	G	6.67×10^{-11} N.m^2/kg^2
Gas constant	R	8.314 J/K.mol
Hydrogen ground state	E_o	-13.6 eV
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Compton wavelength	λ_c	2.426×10^{-12} m
Planck's constant	h	6.626×10^{-34} J.s
Speed of light in vacuum	c	3.0×10^{8} m/s
Rydberg constant	R_H	1.097×10^{7} m^{-1}
Acceleration due to gravity,	g	9.81 m /s^2
Atomic mass unit (1u)	u	1.66×10^{-27} kg
Avogadro's number	N_A	6.023×10^{23} mol^{-1}
Threshold of intensity of hearing	I_o	1.0×10^{-12} W /m^2
Coulomb constant	k	8.988×10^{9} N m^2/C^2
Permittivity of free space	ϵ_o/κ_o	8.85×10^{-12} C^2/N.m^2
Permeability of free space	μ_o	$4\pi \times 10^{-7}$ H/m

Energy equivalent of atomic mass unit:

One atomic mass unit (1.0 u) is equivalent to 931.5 MeV

APPENDIX II

List of formulas

$$A_v = \frac{V_c}{V_b}$$

$$\alpha_{dc} = \frac{\beta_{dc}}{\beta_{dc}+1}$$

$$\beta_{dc} = \frac{\alpha_{dc}}{1-\alpha_{dc}}$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \mu_0 n I$$

$$\xi = V + Ir$$

$$\xi = blv$$

$$\xi = -N\frac{\Delta\Phi}{\Delta t}$$

$$\xi = -L\frac{dI}{dt}$$

$$\xi = -M\frac{dI}{dt}$$

$$F = BIL\sin\theta$$

$$F = qvB\sin\theta$$

$$\frac{F}{\ell} = \frac{\mu_0 I_1 I_2}{2\pi d}$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$I_{tot} = \sqrt{I_R^2 + (I_L - I_C)^2}$$

$$I = neA(v_n + v_p)$$

$$I = nev_d A$$

$$I = I_{max}\sin\omega t$$

$$I_{rms} = \frac{I_{max}}{\sqrt{2}}$$

$$I_x = \left(\frac{R_T}{R_x}\right)I_T$$

$$L = \frac{N\Phi_B}{I}$$

$$L = \frac{\mu_o N^2 A}{l}$$

$$M = \frac{N\Phi_B}{I}$$

$$M = \frac{\mu_o N_1 N_2 A}{l}$$

$$P = IV = I^2R = \frac{V^2}{R}$$

$$P_t = I_{rms}V_{rms}\cos\phi$$

$$P_r = V_{rms}I_{rms}\sin\phi$$

$$P_a = I_{rms}^2 Z$$

$$R = \frac{\rho L}{A}$$

$$R = R_0\left[1+\alpha\left(T-T_0\right)\right]$$

$$R_T = R_1 + R_2 + R_3 + \ldots$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

$$r = \frac{mv}{Bq}$$

$$\tau = NBIA\sin\theta$$

$$U = \frac{1}{2}LI^2$$

$$U = \frac{1}{2}B^2 A\frac{l}{\mu_o}$$

$$V_H = Bvd$$

$$V = V_{max}\sin\omega t$$

$$V_{rms} = \frac{V_{max}}{\sqrt{2}}$$

$$V_x = \left(\frac{R_x}{R_T}\right)V_S$$

$$X_C = \frac{1}{2\pi fC}$$

$$X_L = 2\pi f L$$

$$Z = \sqrt{R^2 + \left(X_L - X_C\right)^2}$$

$$\oint B.dl = \mu_o I$$

$$d\mathbf{B} = \frac{\mu_O I}{4\pi}\frac{d\ell\times\hat{\mathbf{r}}}{r^2}$$

$$\Phi_B = BA\cos\theta$$

$$\cos\phi = \frac{R}{Z}$$

$$\tan\phi = \frac{X_L - X_C}{R}$$